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COMPUTER-AIDED DESIGN OF SUPPRESSIVE SHIELDS

Final Report

by

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DEPARTMENT OF THE ARMY
Edgewood Arsenal
Aberdeen Proving Ground, Maryland 21010

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Engineering design procedures are being developed, safety approved, and organized into systematic procedures for application of suppressive structures in US Army ammunition plants. The approved procedures will include use of complex computer programs and charts in time consuming, iterant methods. A study has been conducted to determine computer software, hardware, and terminal requirements; and to estimate computer equipment and operation costs. The results of that study as reported herein indicate a considerable cost savings can be expected by use of computer-aided procedures in design of suppressive shields.

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PREFACE

The investigation described in this report was authorized under Contract DAAA15-75-C-0120, Task 2, Computer-Aided Design of Suppresive Shields. This report was prepared for the Suppressive Shielding Branch, Manufacturing Technology Directorate, Edgewood Arsenal in support of the Manufacturing Methods and Technology Project 5751264. This work was completed in March 1976.

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COMPUTER-AIDED DESIGN OF SUPPRESSIVE SHIELDS

I. INTRODUCTION

This study was conducted to determine the feasibility of applying computer-aided design (CAD) techniques and procedures to the design and design evaluation of suppressive shields. At present, some 200 suppressive shield applications have been identified in the Munitions Production Based Modernization Program. The present design procedure is costly and time consuming. The use of CAD techniques in design and design evaluation of suppressive shields will minimize design time and cost, improve design by incorporating optimized and safety approved methods, provide the ability to analytically evaluate designs, and provide consistent, efficient, and accurate design procedures.

The current Edgewood Arsenal Suppressive Shielding Program will culminate in an engineering design handbook which will be used by architectural and engineering contractors who prepare designs and specifications for new or modernized munition production facilities. CAD procedures are planned as an integral portion of this Suppressive Structures Handbook. These CAD procedures will handle the tedious iterations of numerous and complex hand calculations. Eventually, the complete design procedure will be computerized and interactive terminal software will be the interface between the computer and the design engineer.

This type of CAD system requires a large computer system capable of conducting a multi-user time share operation with fast response. Many such computer systems are available within the Government; one is the Edgewood Arsenal computer facility consisting of the UNIVAC 1108 computer system. The EXEC VIII operating system of the UNIVAC 1108 allows interactive terminals to operate from remote areas via standard telephone communications.

II. CURRENT DESIGN METHODS

In the design of a suppressive shield, there are three main areas of engineering effort:

A. Analysis of the environment

B. Shield design

C. Analysis of the design

There is feedback from each of these areas and each area employs a number of analysis disciplines. Some computer programs are available to aid the analysis, particularly in the analysis of blast and fragment effects. Also available are some guidelines based on previous suppressive shield designs.

III. CAD APPLICATION

A. Equipment Configuration.

The general CAD equipment configuration is shown in figure 1. The CAD application at the design station would incorporate an interactive terminal located in the design area and connected to a computer system similar to Edgewood Arsenal's UNIVAC 1108 via telephone lines. This design station would consist of an interactive graphics CRT with a hard copy unit for display of results, and a keyboard typewriter for input and control. The Suppressive Structures Handbook will define the specific design procedure. The designer would enter, via a typewriter terminal, the commands for the desired type of analysis and the input for that analysis. Results would be displayed on the CRT in tabular and graphical form. The designer would be able to make a hard copy of the results for further study. The terminal would require a low speed data communications modem. Since this arrangement would only require a standard telephone set, the location of the design station would be flexible.

A system such as the Edgewood Arsenal's UNIVAC 1108 computer system will be required for this application. Resident on that system could be a monitor program for servicing the terminal requests. This monitor program will operate within the teleprocessing software of the operating system, and will bring in the analysis programs required as a result of the specific request. The analysis will be taken from the engineering design handbook. These analysis programs will reside on a mass storage device such as disk or high speed drum as a Suppressive Structures Design Code file. These programs will use design parameters which will reside in the Suppressive Structures Data Base. This data base will also reside on a mass storage device.

The system also could generate information for an artwork generator consisting of a minicomputer and plotting system for generating drawings.

B. Suppressive Structures CAD Procedure.

The design procedure is divided into the donor system analysis and the shield design analysis. A block diagram of the design flow is shown in figure 2.

The donor system analysis is conducted to determine the hazard environment. The engineer/designer enters the donor system characteristics which define the munition configuration. Then the blast, fragment, and thermal characteristics are determined as shown in figure 2. These results are displayed and stored on disk or drum for use later by the design program. This part of the system defines the hazard environment and is not a part of the design. Rather, the results of this sytem are used as input to the design.

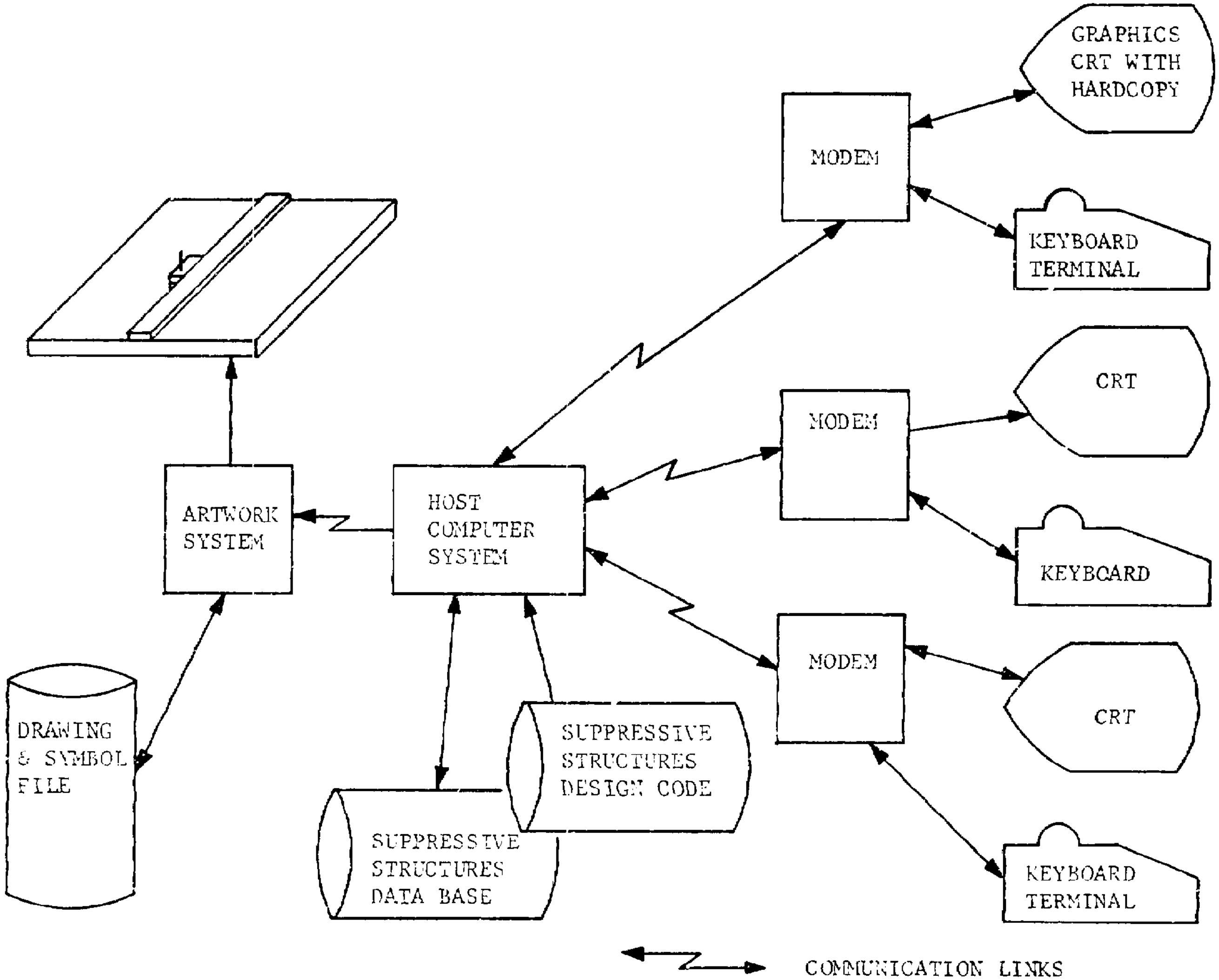

FIGURE 1. EQUIPMENT CONFIGURATION

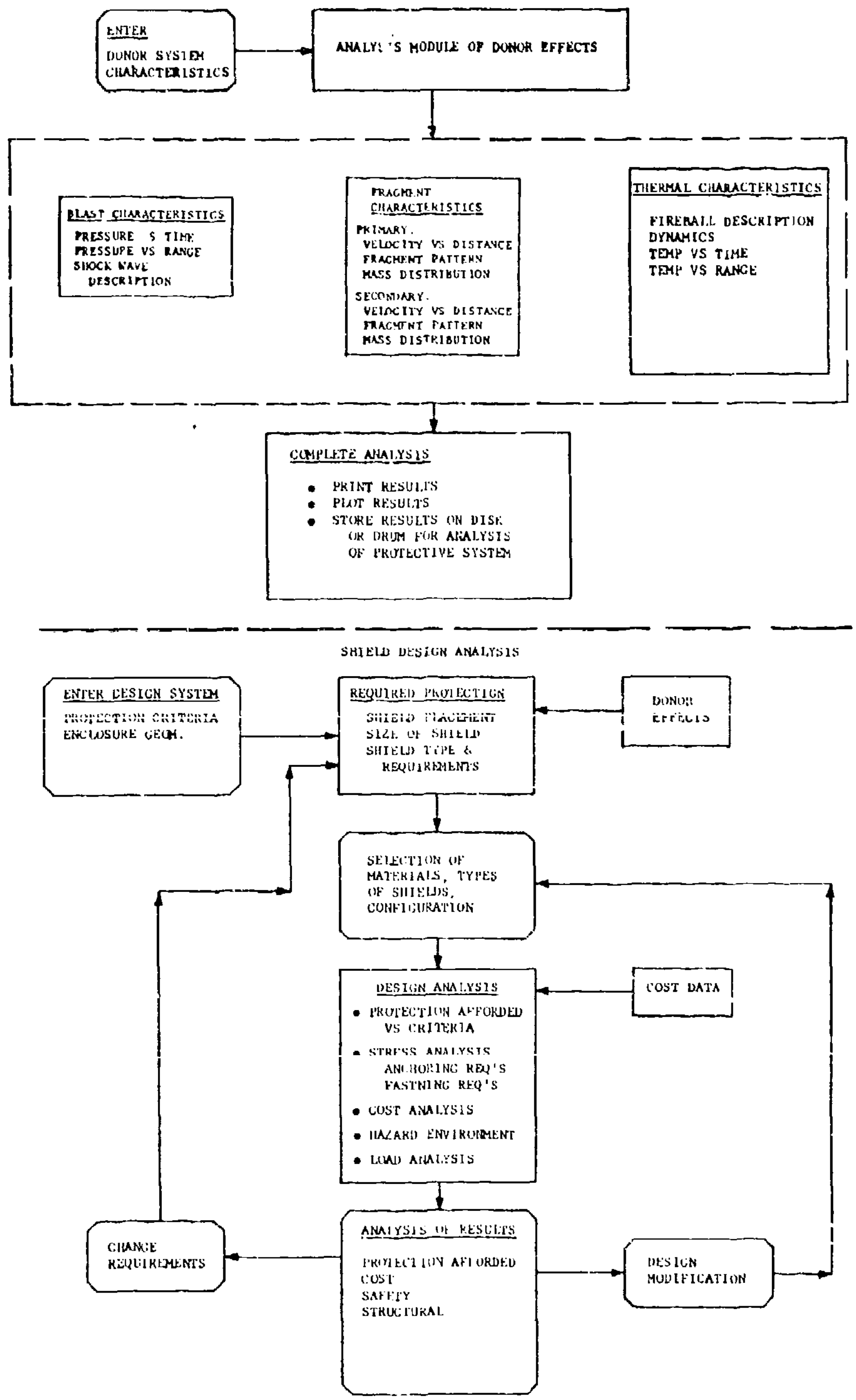

FIGURE 2. DONOR SYSTEM ANALYSIS

The shield design analysis system is the major portion of the CAD environment. Here the engineer/designer first tells the system the degree of protection that is desired and the geometry of the environment. The system then uses the results of the donor system analysis and displays information on the CRT concerning the required shield configuration. The engineer then works interactively with the machine to select materials, type of shield, configuration, etc. The machine, based on previous design information, provides him with results of previous designs. When he has developed the design concept, the system analyzes that design with respect to effectiveness and cost and then displays the results. Upon his interpretation of the results, the designer can modify the design and analyze it again or he can change the requirements if the design is not feasible due to the constraints placed on the requirements. It is important to note that the designer makes the final decision and the system provides him with the information to make that decision.

C. Data Flow.

The system consists of three program modules with five data bases and a file maintenance module. The data flow is shown in figure 3. These modules are defined as follows:

1. Munitions Effects Module.

This system consists of a control program, munition analysis programs, a files control program, and a results presentation program. The control program is the interface between the engineer and the machine. It honors his requests and loads those programs to conduct the required analysis. The munition analysis programs are three separate programs consisting of a blast effects program, a fragmentation effects program, and a thermal effects program. This area is the only part of the total system where existing computer programs may be utilized. The applied technology effort on the current suppressive shield project determines the existing programs that most effectively apply to this analysis. The files control program creates the blast, fragment, and thermal effects file to be used during the design analysis. The results presentation program formats the results for presentation in summary form at the designer's console or in a detail tabular presentation.

2. Design Requirements Module.

This module consists of a control program, a files program, a design program, and a results presentation program. The control program is the interface between the engineer and the machine. The design program analyzes the protection criteria and enclosure geometry, obtains the hazard data program from the effects file, and determines the specific hazard to that environment. It then uses the files program to obtain information from the shield data base and to determine the shi ld parameters to meet the

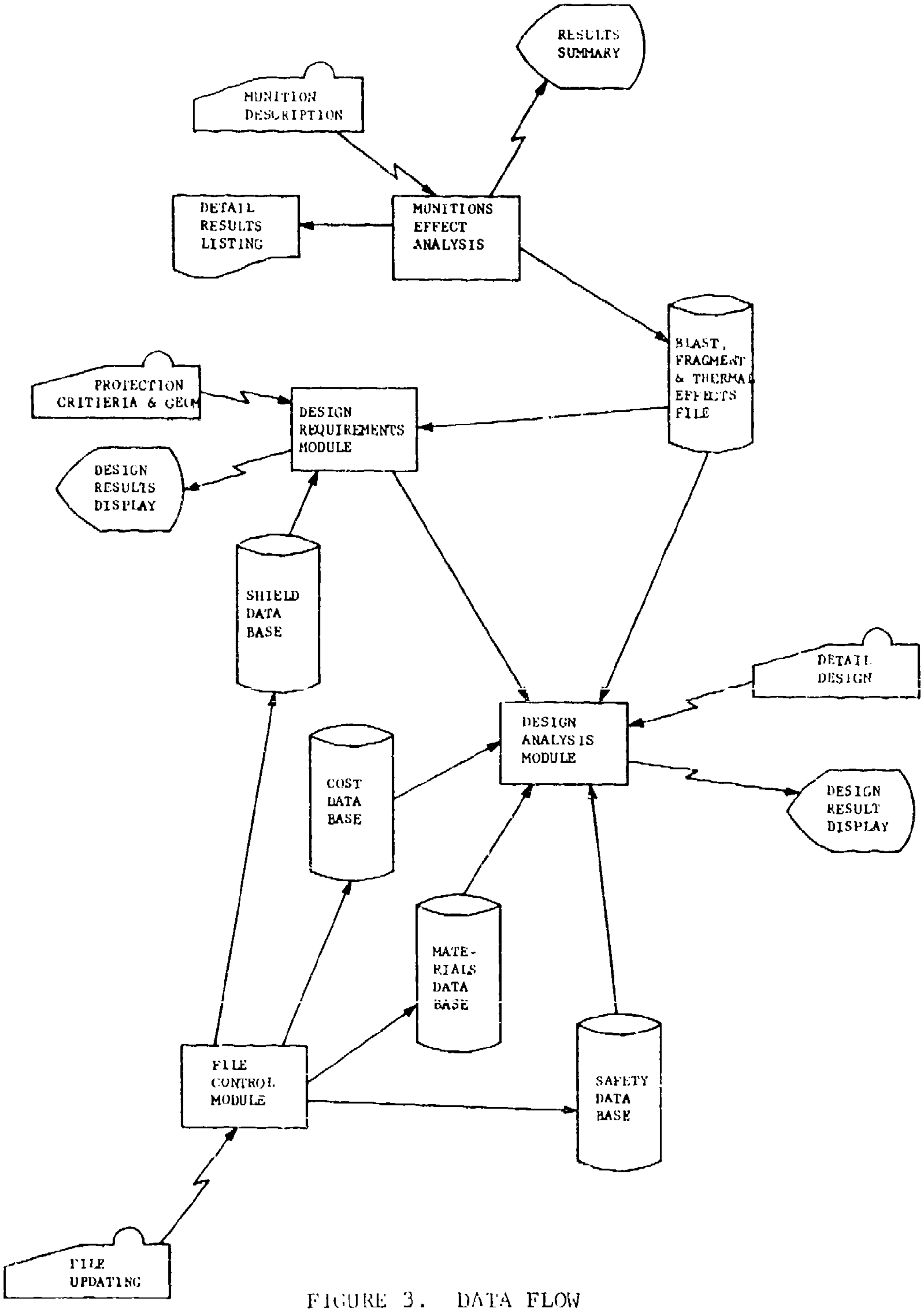

FIGURE 3. DATA FLOW

designer's constraints. The results presentation program provides a display of the hazard encountered and shield performance as a function of the options the designer can use in the design.

3. Design Analysis Module.

This module consists of a control program, a design program, a design analysis program, a files program, and a results presentation program. The control program again interfaces the man and the machine. The design program requests specific design information from the engineer and, on request from the engineer, provides him with information from the materials data base. The design analysis program conducts design optimization and, using information from the cost data base and the safety data base, analyzes the effectiveness of the design concept. The files program provides interface with the data base. The results presentation program provides the results to the engineer in tabular and graphical form.

4. Files Maintenance Module.

This module provides the capability to update and maintain all all the data bases of the system.

IV. IMPLEMENTATION

The detailed implementation of the CAD Suppressive Shields system will be a coordinated effort between the design engineers, engineering analysts, programmers, and computer facility operations personnel. A preliminary implementation schedule is shown in figure 4. The task definitions and level of effort follows:

1. System Specification - This 2 month effort will result in a detailed concept of the overall system. The specification will present in detail the analysis, operation, data base structure, program modules, and data flow for the entire system. This effort will involve personnel from all required operations. Level of effort - 6 man months.

2. Analysis Phase - This task will obtain all analyses to be used and will develop program algorithms that will be required. Level of effort - 8 man months.

3. Program Module Specifications - This task will develop detailed specifications for each program module. They will include flow charts, variable name dictionaries, block diagrams, etc. Level of effort - 21 man months.

4. Procurement Phase - This task will obtain necessary terminal hardware to be used in the system. It is important that this equipment be obtained for the programming and checkout phases - equipment cost $12,000.

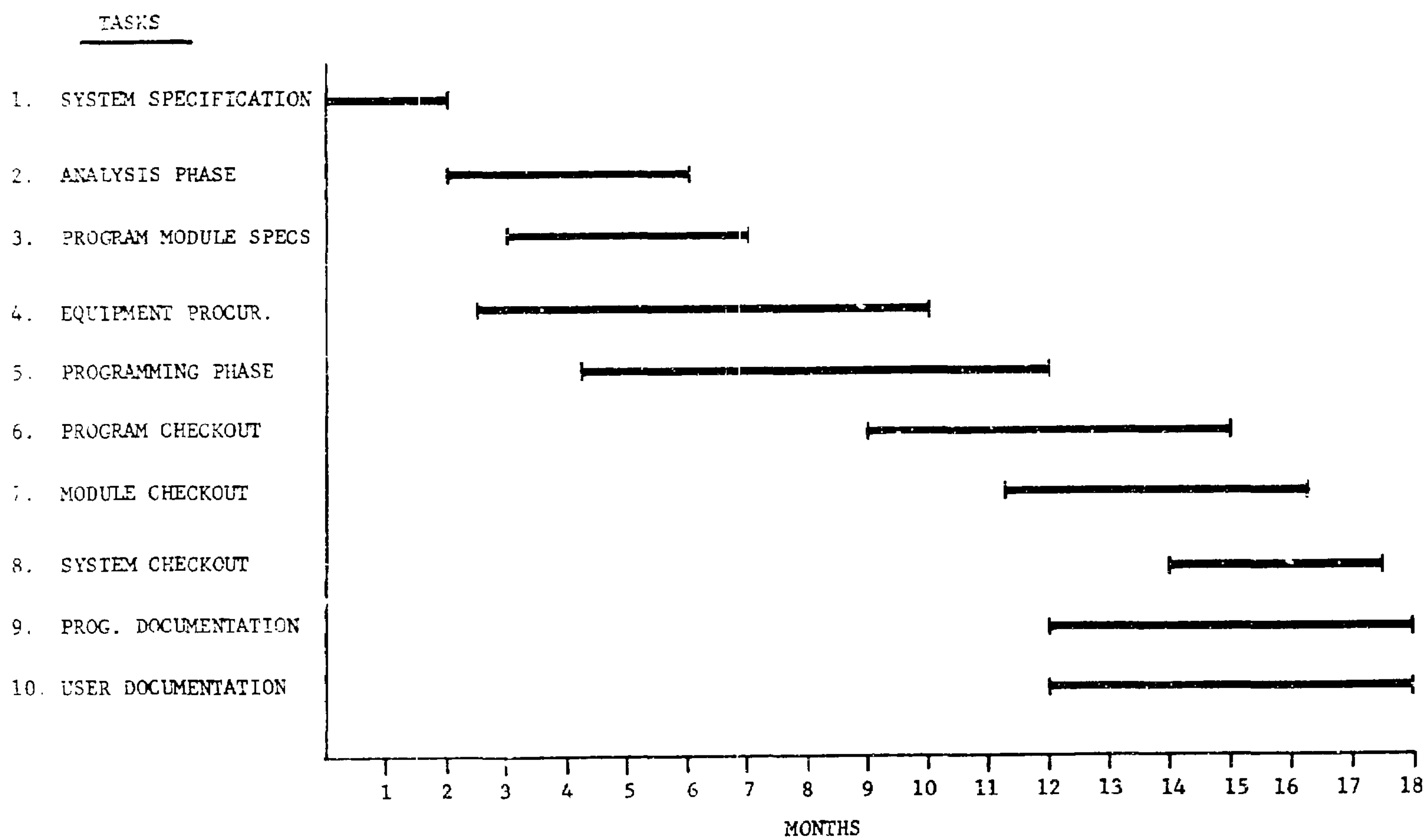

FIGURE 4. IMPLEMENTATION SCHEDULE

5. Programming Phase - This task will generate the actual code for the program modules. Level of effort - 32 man months.

6. Program Checkout - This task will verify the individual programs on the computer system. Level of effort - 18 man months.

7. Module Checkout - This task will verify and check out the program modules consisting of groupings of the individual programs. Level of effort - 15 man months.

8. System Checkout - This task will verify and check out the overall system consisting of the program modules. There will be much interaction between tasks 5, 6, 7 and 8. Level of effort - 9 man months.

9. Program Documentation - This task will provide detailed documentation of the logic flow and construction of the programs to enable ease of maintenance and modification. Level of effort - 12 man months.

10. User Documentation - This task will provide detailed documentation defining the use of the system. This explicit set of instructions and definitions will form a part of the engineering design handbook - 12 man months.

In addition to these tasks, 12 man months should be allocated to management of this effort. Total level of effort is 152 man months and $12,000 for equipment for a total cost of approximately $500,000.

V. COST SAVINGS

The cost data is shown in figure 5 and the projected savings by year is shown in figure 6. The manual design costs per shield and the projected number of shields per year were obtained from experience at the Suppressive Shielding Branch, Mechanical Process Technology Division, Manufacturing Technology Directorate, Edgewood Arsenal. The design costs using CAD were estimated from discussions with personnel familiar with the CAD procedure and were then compared with the costs of the present suppressive shield design procedure.

VI. CONCLUSIONS AND RECOMMENDATIONS

It is concluded that computer-aided design procedures are applicable to the design of suppressive shields. Use of these procedures will improve accuracy of design calculations. Suppressive shields designed by these procedures will be more reliable and economical than those designed by manual design calculations.

It is recommended that a Manufacturing Methods and Technology project to apply computer-aided design procedures to design of suppressive shields be initiated as soon as possible after the engineering design handbook is completed.

		CAT 1-5				CAT 6			
		MANUAL		CAD		MANUAL		CAD	
		HRS	COST $\$ \times 10^3$	HRS	COST $\$ \times 10^3$	HRS	COST $\$ \times 10^3$	HRS	COST $\$ \times 10^3$
ENG HRS @ $25/HR		200	5	80	2	80	2.0	33	0.8
DES HRS @ $20/HR		400	8	150	3	200	4.0	60	1.2
TOTAL DESIGN		600	13	230	5	280	6.0	93	2.0
SAFETY	INPUT LEVEL	80	2	40	1.0				
	PIC. ARS	80	2	40	1.0				
	COMMAND	40	1	20	.5				
	AMC	20	.5	10	.25				
	EXPL SAFETY BOARD	20	.5	10	.25				
	TOTAL SAFETY	240	6	120	3	240	6	80	3
TOTAL			19		8		12		5

FIGURE 5. COST PER SHIELD

YEAR	NO. OF DESIGNS		MANUAL COSTS		CAD COSTS			SAVINGS
	CAT 1-5	CAT 6	DESIGN COSTS	SAFETY REVIEW	DEVEL & EQUIP	DESIGN COSTS	SAFETY REVIEW	
1978					335	-	-	(335)
1979	-	-			245			(245)
1980	12	-	156	72		60	36	132
1981	14		182	84		70	42	154
1982	20	60	620	480		220	240	640
1983	20		260	120		100	60	220
1984	8	60	464	408		160	204	508
1985	16		208	96		80	48	176
1986	25	60	685	510		245	255	695
1987	13	0	169	78		65	39	143
TOTAL	128	180	2744	1848	580	1000	924	2088

COSTS IN $ x10^3

FIGURE 6. PROJECTED SAVINGS

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